EXPLORING INTELLECTUAL AUTHORITY IN WORK-SHARING INTERACTIONS IN ONE SIXTH-GRADE MATHEMATICS CLASSROOM

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Opportunities for students to share their thinking with the class—which I refer to as "work-sharing practices—require a profound shift in who is positioned with intellectual authority in mathematics classrooms. This study explores work-sharing practices in one sixth grade mathematics classroom through an interactional lens. Video analysis revealed three types of work-sharing interactions along a continuum of distributions of intellectual authority, ranging from the presenting student holding authority to the teacher holding authority. Notably, in the center of the continuum were instances in which the student was initially positioned with authority, but that authority shifted to the teacher in the next moment, largely based on correctness of the student's work. Findings suggest the need to deepen our understanding of authority dynamics in work-sharing interactions, as the field works to center students' thinking.

Keywords: Instructional activities; equity; classroom discourse

Purpose of study

For the past several decades, mathematics education researchers and policymakers have called for increased opportunities for students to generate their own mathematical strategies, to share that thinking with their peers, and to critique their peers' reasoning (Common Core State Standards, 2013; National Council of Teachers of Mathematics, 2000; California Department of Education, 2021). Research has shown that teachers can implement specific pedagogies to elicit, attend to, and build on students' mathematical ideas (Carpenter et al., 1996; Fennema et al., 1993), leveraging students' novel thinking as an instructional resource for their peers' learning (Singer-Gabella et al, 2016) and supporting students to engage with each other's thinking (Franke et al 2015). These instructional strategies have been shown to be both effective and equitable in terms of increasing students' opportunities to learn (Bartell et al, 2017).

Opportunities for students to share their thinking with the class—which I refer to as "work-sharing practices"—require a profound shift in who is positioned as holding intellectual authority in mathematics classrooms. Whereas teachers and students typically position the teacher, textbook, and/or mathematics itself as the authority in traditional math classrooms (Amit & Fried, 2005), inviting students to share their thinking with their peers reconfigures the classroom such that students come to be viewed as active constructors—rather than passive receivers—of knowledge who can author their own ideas (Boaler & Greeno, 2000). Work-sharing practices have the potential to shift the social negotiation of authority in classrooms (Langer-Osuna, 2016), to redefine and expand who is seen as competent (Gresalfi et al, 2009), and to subvert narrow and racialized notions of mathematical ability (Louie, 2017; Shah, 2017).

Like any pedagogy, work-sharing practices can be implemented in a range of ways, such that the extent to which students are positioned with intellectual authority and their thinking is physically and intellectually centered may vary across classrooms. Many studies have examined work-sharing in terms of teachers' instructional moves (Smith et al, 2011; Franke et al, 2015), viewing the teacher as the main determinant of how students share their work and how they come to be viewed by their classmates. Given the co-constructed and dynamic nature of

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classroom interaction (Philip et al, 2020), however, there is much to be learned about how teachers and students construct these practices in and through interaction. Within work-sharing interactions, some students may be positioned with authority while others may not be (Wood, 2013; Langer-Osuna, 2016) and some students' ideas may be privileged while others may be silenced (Leander, 2002). Unpacking the ways in which intellectual authority is distributed across and shifts within work-sharing interactions is essential to the implementation of pedagogies that robustly and equitably center students' thinking. This case study of one sixth-grade math classroom explores work-sharing through an interactional lens to investigate:

6. How is intellectual authority distributed during work-sharing practices?
7. When and under what conditions does intellectual authority shift in the moment, if at all?

Theoretical framework

I draw on literature on interactional positioning and intellectual authority within mathematics classrooms. Cobb and colleagues (1996, 2001) defined "classroom mathematical practices" as mathematical activities that become established over time and are locally and jointly constructed by students and teachers through interaction. In this study, I use the term "practices" to refer to co-constructed interactional routines in which students share their mathematical work publicly during whole-class discussions. Viewing work-sharing practices as constructed by teachers and students through interaction affords lenses on how teachers and students position themselves and each other, which may be consequential for how authority is distributed (Cobb et al, 2009).

To consider how some participants in a practice come to be seen as holding intellectual authority in particular moments, I draw on the construct of positioning. Davies and Harré (1990) define moment-to-moment positioning as, "the discursive process whereby selves are located in conversations as observably and subjectively coherent participants in jointly produced story lines" (p. 48). The authors define two types of positioning: interactive, in which one person positions another, and reflexive, in which one positions oneself. As an iterative process, interactional positioning enables us to consider the moment-to-moment locations that students may hold within an interaction, as positioned by themselves and by others through verbal and nonverbal communication. In-the-moment positions within learning environments are shaped by a range of factors, from local co-constructed notions of what it means to be mathematically competent (Gresalfi et al, 2009) to racial and gender categories (Gholson & Martin, 2014).

The extent to which students are positioned as having intellectual authority within mathematics classrooms is of particular importance, in light of current recommendations for students to author their own strategies and to share that thinking with their peers (CCSS, 2013), which depart from dominant forms of instruction that position mathematics as a discipline as the authority (Amit & Fried, 2005). Building on Cobb et al (2009) and Engle et al (2014), I consider intellectual authority in work-sharing to be the extent to which students position themselves reflexively and/or are positioned interactively by their peers and their teacher as a credible source of information in relation to their mathematical contributions. Further, I draw on Engle and colleagues' (2014) influence framework to consider two linked components that relate to the negotiation of students' authority: their access to the conversational floor (i.e. the degree to which they can initiate and complete turns of talk when desired) and to the interactional space (i.e. the degree to which they are visually and physically attended to by others when speaking).

The extent to which students position themselves and get positioned by their peers and teacher with intellectual authority can have material consequences, decreasing opportunities to

contribute to groupwork (Esmonde, 2009) and to identify with mathematics (Langer-Osuna, 2011, Cobb et al, 2009). Much of this work focuses on interactional positioning and authority in collaborative contexts (Wood, 2013; Langer-Osuna, 2016); however, Turner and colleagues (2013) note that whole-class discussions are distinctive in that they "afford opportunities for students to take on roles publicly" (p. 203). Sharing work in the whole-class space thus affords students opportunities to position themselves or to be positioned publicly with authority, which may be particularly consequential for their engagement in and identification with mathematics.

Methods

Study Setting & Participants

I use ethnographic approaches (Emerson et al, 2011) to characterize these practices at the classroom level and interaction analysis (Jordan & Henderson, 1995) to uncover how students are positioned in moments of sharing. The sixth-grade mathematics teacher in this study, Ms. L,[6] was selected because she engages students in sharing their thinking with the class. This was determined through initial conversations and then verified during observations in the fall of 2021. Change Academy, where Ms. L teaches, is a public charter school in a small city in Northern California that serves a majority working-class student population. There were 30 students in Ms. L's class during the study, most of whom identified as Latinx, with the remaining students identifying as Filipinx, East Asian, and/or Black. Ms. L identifies as Vietnamese-American. Four of the focal students identify as Latinx and the other two identify as Filipinx. Three are female-identifying and three are male-identifying. Catalina, the focal student whose work is featured in this paper, identifies as a Mexican American female.

Data Sources & Analysis

The primary data source consisted of 13 hours of classroom video, recorded daily during a geometry unit in spring 2022. Additional data sources were used to triangulate video analysis: fieldnotes from throughout the unit and semi-structured interviews (Glesne, 2005) with six focal students at the end of the unit. Focal students were selected to be representative of the class, in terms of race, gender, achievement, and participation. Five focal students had shared work during the video recorded unit and were shown a picture of them sharing in the interview.

To begin data reduction, a time-indexed content log (Derry et al, 2007) of the video recording was created that outlined work-sharing activities across the 13 hours. Work-sharing activities (n = 15) were defined as instances in which: 1.) a representation of the student's work was made publicly visible to the class, 2.) that student stood at the front of the classroom speaking about it. Following Angelillo and colleagues' (2007) approach to examining video interactions, each instance was viewed multiple times across several rounds of analysis. In the first round, analytic memos were constructed about each instance, in relation to reflexive and interactive positioning of the presenting student and their ideas (Davies & Harré, 1990), the extent to which correctness was determined (as noted in Esmonde, 2009), and teacher framing and class engagement more broadly. These memos revealed patterns in how intellectual authority was distributed across instances and seemed to shift between the presenting student and the teacher in particular moments. This revelation led to additional memos in conversation with the literature on intellectual authority in classrooms (Cobb et al, 2009; Engle et al, 2014; Langer-Osuna, 2016; Amit & Fried, 2005). In the second round of analysis, each work-sharing instance was broken into several "interactional states" (Langer-Osuna et al, 2020), between which

[6] All teacher, student, and school names are pseudonyms.

authority seemed to shift. Using Engle and colleagues' (2014) influence framework as a guide, analytic memos were written about each interactional state, in relation to who had access to the interactional space and the conversational floor, who was positioned as having intellectual authority, when positioning around authority seemed to shift, and what interactive and reflexive positioning acts made these shifts possible. Following this round of analysis, additional memos were written about each activity, which noted under what conditions authority seemed to shift between states and from which the continuum of three distributions emerged. Finally, student interviews were transcribed and open coded for emergent themes, after which analytic memos were written to connect students' reflections on the moments in which they shared their work (in the interview) to the interaction analysis of those same moments (in the video).

Results

Video analysis revealed that intellectual authority was distributed in distinct ways across the set of work-sharing interactions and that it shifted within some work-sharing interactions. Of the 15 instances of work-sharing that occurred during the video recorded unit, three types of interactions emerged along a continuum of distributions of intellectual authority. On one side of the continuum were "expert student" interactions (n = 6) in which students were positioned as having intellectual authority for the majority of the interaction. On the other side of the continuum were "teacher mediated interactions (n = 3) in which the teacher positioned herself as the intellectual authority, despite the student occasionally having access to the conversational floor. In the center of the continuum were "student to teacher" interactions (n = 6) in which students were initially positioned as having intellectual authority on their work but at some point during the interaction the teacher undermined their authority and positioned herself as the authority on the mathematics. These types are defined in table 1 and explored further below.

Table 1: Continuum of authority distributions across work-sharing interactions

Expert student	Student to teacher	Teacher mediated
Student positioned as authority for majority of clip	Student initially gets positioned as authority, but during work-sharing the teacher withdraws that authority and positions herself instead as mathematical authority.	Teacher positions self as authority, despite students having access to the floor
Student ⟷ Teacher		

RQ1: Distributions of Intellectual Authority

In "expert student" instances (n = 6), the presenting student was positioned as an intellectual authority on their work by Ms. L, their peers, and in some cases themselves. These instances typically began with Ms. L telling the class to "follow along" and "have eyes and ears up here so we can pay attention to our classmate" and telling the presenting student to "show us how you got…" This language positioned the presenting student as someone to learn from and to pay attention to, as well as someone capable of actively "showing" the class their thinking. The presenting student then walked up to the whiteboard in the front and stood in the center, as Ms. L moved to the side of the whiteboard and told them to "go ahead." This physical movement, combined with the verbal signal from Ms. L to "go ahead," effectively granted the student access to the interactional space and the conversational floor. The presenting student stood at the front, pointing to their work and explaining their reasoning, sometimes annotating it with a whiteboard marker at the same time. In these ways, many of these students reflexively positioned themselves

with confidence in their thinking. After the student finished explaining, Ms. L asked the class if they agreed with their classmate and simultaneously motioned an agreement signal herself, which many students immediately mirrored back or gave a thumbs up. Ms. L then asked the class if they had questions for the presenting student "especially if you got a different value," positioning that student as a credible source of information and positioning their work as an answer key that other students could use to check their work against. In two of these six instances, a student asked a question directly to the presenting student (e.g. "Why did **you** draw…?"), positioning them as capable of explaining their own thinking. These instances ended with Ms. L thanking the presenting student, the class clapping for them, and them sitting down. This co-constructed closure seemed to signal the end of the work-sharing interaction and of several minutes of that student being positioned as an intellectual authority.

One example illustrates the variation of positioning in these interactions. When Ms. L called on Abigail to share, she was initially reluctant to come up. Ms. L encouraged her to share, saying "You can do this!" and her classmates cheered "Go Abigail!" as she eventually walked up to the board. Once at the front, Abigail drew out and explained her method for decomposing and rearranging a parallelogram into two rectangles to find its area. After she finished explaining, her classmates applauded unprompted, despite this applause usually happening right after Ms. L thanked the student for sharing. Ms. L then asked the class if they had questions for Abigail and one student asked her to explain why she had decomposed the shape that way. In this example, Abigail did not initially position herself as an intellectual authority, however, her classmates and teacher did through encouragement, unprompted applause, and a question about her work.

In "teacher mediated" instances (n = 3) at the other end of the continuum, the presenting student was not positioned as an intellectual authority, despite standing in front of the class. In these instances, students were called up to annotate a shape projected to the whiteboard, rather than having a photograph of their work projected or writing out their work on the whiteboard in real-time. These students did not explain their reasoning, but instead stated their answer at the front, after which Ms. L began asking Initiate-Response-Evaluation (Mehan, 1979) questions to them or the class. In these instances, the work that was shared was initially incorrect or incomplete. Throughout Ms. L's IRE questioning, Ms. L either modified the projected work or another student came up to add to it. In cases of the latter, despite the initial presenting student and the student who came up standing at the front together, they did not talk directly to each other, but instead the conversation was mediated through Ms. L. Unlike the expert student interactions, these instances did not have a consistent form of closure. In one case, a student sat down while Ms. L spoke (without being thanked or clapped for) and in the other two cases, Ms. L thanked the presenting student but there was no applause. These instances resembled less of a performance that centered one student's thinking and more of a moment in which students were briefly physically, but not intellectually, centered.

In the center of the continuum were "student to teacher" instances (n=6), which began much like the expert student clips but ended more similarly to the teacher mediated instances. Because these instances involved distinct shifts in terms of who was positioned with authority, I explore them in more detail in the following section.

RQ2: Shifts in Authority

In student to teacher interactions, the presenting students were initially positioned with authority as they stood at the front, explained their thinking, and pointed to their work. After their explanations, however, that student's access to the interactional space and the conversational floor, as well as their positioning as an authority, were undermined. An example

is shown below during which Catalina came up to show how to find the area of a triangle. The problem was projected on the white board and Catalina drew on the projected triangle with a whiteboard marker (see figure 1). Catalina explained her thinking while drawing:

Ms. L	Go ahead, Catalina. [moves to the side]
Catalina	[picks up whiteboard marker and begins writing with it] Okay um, so what I did um…what I did is…I tried to draw a line right here [draws dotted line segment] to make it a lot more bigger [draws another dotted line segment], expanding it. And then what I did, I took the piece, I took the little index card [picks up index card] and lined it up right here [puts it in the corner of one vertex of the triangle], so it's right, so I chose this to be my base [writes "b" above side of triangle]. Um, I moved it right, I moved it right here, and I put it right here [moves index card along the base], moved it over here, to reach this corner, which is the vertex, which is my opposite vertex. Then I tried to also expand this right here [draws another dotted line segment], so it's easier for me to count. And this base turned into [points to base and moves finger along length of base], turned into 12 [moves hand to write above the base, then takes it off], this turned into [counts each unit square in the base and dotted line extension] 15, turned into 15 [writes 15 above the base]. And this was [points to dotted line height] 8 [writes 8 next to dotted line]. And, uh, I did 15 times 8 [writes out 15 x 8 next to triangle], which is 120 [writes = 120]. Uh, so, my total, is 120 square units [writes square units]. [caps marker and turns to face Ms. L]
Ms. L	What is the formula to find the area of a triangle? What did we say earlier? Compared to a parallelogram?
Catalina	Um…
Ms. L	Do you remember?
Catalina	Not really.
Ms. L	Can someone help out? [turns body away from Catalina toward the class]

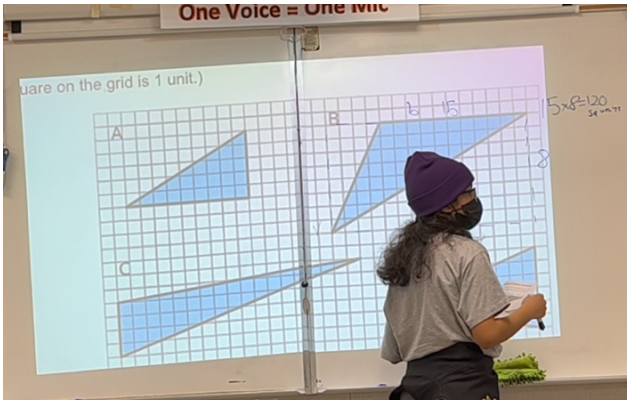

Figure 1: Catalina sharing her work finding the area of a triangle

After this exchange, Ms. L called on another student to share the formula for the area of a triangle and asked several follow-up questions related to the formula. This shifting of the conversation away from the presenting student's strategy to the formula for finding area happened in nearly all of the student to teacher instances. Moreover, in many of these instances Ms. L wrote out the formula next to the presenting student's work and solved the problem that

way, though that did not happen in the Catalina example, perhaps because class ended shortly after the excerpt shown above. In shifting the conversation away from the students' thinking to the formula and in authoring her own representation of the problem, Ms. L undermined Catalina and other presenting students' authority. Interestingly, neither Ms. L nor other students in the class explicitly noted that Catalina's answer was incorrect. Instead, it seemed to be implied that she was incorrect based on Ms. L offering another way to solve the problem and arriving at a different answer. Notably, Ms. L did not ask the class if they agreed with Catalina's work, as was done in the expert instances.

All students in these instances presented work that was incorrect, though some were partially correct and/or employed creative strategies that could have been revised to find the area accurately. Like the Catalina example, neither Ms. L nor the other students explicitly shared that the work was incorrect in these instances, yet it seemed to be implicitly communicated through the offering of another strategy with another answer. In many instances, the presenting student stood up at the front while Ms. L authored another strategy on the whiteboard. Typically, Ms. L gradually moved to the center as she wrote and the student gradually backed up to the side. In this way, the student lost access to the physical interactional space. In most of these instances, the presenting student never regained access to the conversational floor after this moment, though in one case the student had a brief opportunity to explain their work again. These interactions typically ended with Ms. L thanking the student and the class applauding, which might be read as an affirmation of the presenting student's effort.

Correctness emerged as the condition under which authority shifted within a work-sharing interaction, as all students in the "expert student" interactions presented work that was deemed to be correct by the teacher and the class through agreement signals, whereas all students in the other two instances had authored work that was partially or fully incorrect or incomplete. It should be noted that the identity of the presenter did not seem to be a condition under which authority shifted within an instance, as some students participated in interactions of all types. In other words, there was one student who shared work in both expert student instances and teacher-mediated instances and another who shared work in all three types of instances.

Although correctness determined authority shifts, it was not a prerequisite for sharing. While in some cases students volunteered to share and in others Ms. L selected students to share, this variation did not correlate with the type of instance. That is, it was not the case, as might be expected, that all students who presented in expert instances volunteered to share or that all students who presented in teacher-mediated instances were selected by Ms. L to share. Additionally, in cases in which Ms. L did select a student to share, this selection was often based on completion rather than correctness, as she noted at the beginning of some instances that she had seen that the presenting student had solved the problem based on scanning the room. In this way, students who had written out their thinking were prioritized in work-sharing, rather than those who may have arrived at the correct answer without documenting their thinking.

Analysis of student interviews confirmed that students were aware of this emphasis on answers and completion. Several students cited the same handful of peers as frequent work-sharers in their classroom, referred to some classmates as smart and others as not, and shared anxiety about being incorrect and getting corrected while presenting. Catalina shared:

> What I felt [when sharing my work] was kind of nervous and anxious that some people didn't really understand…I really felt kind of paranoid, thinking people will probably use what I

said there against me…like correcting me about like, almost everything that—being paranoid that I got almost everything wrong.

In this quote, Catalina noted her fear of being wrong and of being corrected. She then named two students in her class who she worried might correct her, "because they're both really smart."

At the same time, Catalina and others mentioned feeling pride in sharing their work with the class, as she explained: "I felt pretty excited to share my work. I felt really happy since I really—I knew a lot more about it, I was able to solve the problem and get like, an actual answer." Interestingly, students seemed to both relish the opportunity to be positioned with authority and to fear the withdrawal of that authority from Ms. L and their peers through correction.

Discussion & Conclusion

Findings revealed that Ms. L and her students constructed work-sharing practices in which intellectual authority was distributed to presenting students in some instances, but which shifted to Ms. L in other instances. The expert interactions in this study demonstrate that intellectual authority can be distributed to students during work-sharing, reconfiguring traditional authority dynamics in the classroom (Boaler & Greeno, 2000) and creating opportunities for students to share their thinking and engage with their peers' ideas, as has been recommended (CCSS, 2013). In these instances, students wrote and explained their thinking, were physically attended to by their peers and their teacher, and were applauded for and asked questions about their work. We might even think of the expert instances as one way to assign competence to presenting students with lower status (Cohen & Lotan, 2014), as was the case with Abigail who did not reflexively position herself with authority but was positioned this way by her teacher and her peers.

However, the ways in which presenting students' authority was undermined in the student to teacher instances should caution us to look more closely at work-sharing practices. These interactions reveal that who is positioned with authority can abruptly shift in the moment and that these shifts are co-constructed. As Catalina and other students shared in their interviews, they feared being corrected while sharing work not only by their teacher but also by a subgroup of their peers. Students and teachers alike are immersed in rigid notions of mathematical activity as answer-finding (Louie, 2017), which may explain the central role that correctness played in shifting authority. The co-constructed and situated nature of classroom interaction (Philip et al, 2020) demands that we look beyond teacher moves (Smith et al, 2011) to consider how students contribute to classroom practices, as well as the ways in which pacing pressures may incentivize teachers to withdraw authority from an incorrect student, rather than to explore the mistake.

This emphasis on correctness has concerning implications for students. If those with correct answers are positioned with authority and those with incorrect answers have authority withdrawn from them, this pattern not only reinforces rigid notions of mathematical activity (Louie, 2017) but may also hinder students' development of positive mathematics identities (Langer-Osuna, 2011; Cobb et al, 2009), especially for those who often arrive at incorrect answers. Further, this pattern has the potential to be particularly damaging for marginalized students like Catalina, who already contend with racialized and gendered discourses about mathematical ability (Shah, 2017) that seep into classrooms and shape in-the-moment positions (Gholson & Martin, 2014).

Future research might seek to understand not only when authority shifts in these moments, but how those shifts are made possible through discursive moves, such as types of positioning around authority (Wagner & Herbel-Eisenmann, 2014). Unpacking how these shifts happen is essential given the ways in which the distribution of intellectual authority can shape students'

mathematics learning and identities (Langer-Osuna, 2017; Cobb et al, 2009). Researchers and practitioners alike might more closely examine work-sharing interactions to better understand how intellectual authority may be distributed to more students, how it might be undermined and shifted, and, most importantly, how positioning students with authority might be sustained.

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